CLAIMS

1. A method for substantially completely decomposing selected chemical substance(s) in an aqueous solution and/or dispersion, said method comprising the step of exposing an aqueous portion containing a chemical substance(s) to ultraviolet laser irradiation at a suitable wavelength and of sufficient energy for a sufficient period of time substantially to decompose the chemical substance(s) in the aqueous portion.

2. A method according to claim 1 wherein said ultraviolet laser irradiation has a wavelength of about 180 nm to 400 nm and delivers an energy density in the range of about 0.10 to 10 millijoules per square millimeter to said aqueous portion.

3. A method according to claim 1 wherein said ultraviolet laser irradiation has a wavelength in the range of about 180 nm to 193 nm.

4. A method according to claim 1 wherein the total period of time during which the aqueous portion is exposed to the ultraviolet laser irradiation is about 1 second to 10 minutes.

5. A method according to claim 1 wherein the total period of time during which the aqueous portion is exposed to the ultraviolet laser irradiation is less than one second.

6. A method according to claim 1 wherein 90% or more of at least one chemical substance originally present in the aqueous portion is decomposed within an ultraviolet laser irradiation period of less than 15 minutes.

7. A method according to claim 1 wherein the aqueous portion before treatment contains one or more selected chemical substances selected from the group consisting of perchlorates, polychlorinated bi-phenyls, dioxins, 1-4 dioxane, pentachlorophenol, tri- and di-nitro toluene, chlorinated solvents, fluorinated organic compounds, and mixtures thereof.

8. A method according to claim 1 wherein the aqueous portion before treatment contains at least a polyfluorinated straight chain organic acid having at least eight carbon atoms.

9. A method according to claim 1 wherein a catalyst is added to the aqueous portion before or during the ultraviolet laser irradiation step.

10. A method according to claim 1 wherein said ultraviolet laser irradiation is delivered to the aqueous portion in pulses at a pulse rate ranging from about 1 to 50,000 pulses per second.

11. A method according to claim 1 wherein said ultraviolet laser irradiation is delivered to the aqueous portion in pulses at a pulse rate ranging from about 10 to 1000 pulses per second.

12. A method according to claim 1 wherein said ultraviolet laser irradiation is delivered to the aqueous portion in pulses at a pulse rate ranging from about 25 to 100 pulses per second.

13. A method according to claim 10 further comprising the step of selecting a combination of ultraviolet laser pulse rate and energy density so as to deliver to the aqueous portion sufficient laser energy to effect substantially complete decomposition of said chemical substance(s) within a total treatment time of about 15 minutes or less.

14. A method according to claim 10 further comprising the step of selecting a combination of ultraviolet laser wavelength or wavelengths, ultraviolet laser pulse rate and energy density so as to deliver to the aqueous portion sufficient laser energy to effect substantially complete decomposition of said chemical substance(s) within a total treatment time of about 15 minutes or less.

15. A method according to claim 1 further comprising a monitoring step of periodically or continuously monitoring the chemical composition of the aqueous portion during the ultraviolet laser treatment.

16. A method according to claim 15 wherein said aqueous portion is treated with ultraviolet laser light while flowing in a conduit, and said monitoring step is performed continuously during laser treatment at two or more locations along said conduit.

17. A method according to claim 15 wherein said monitoring step comprises the steps of passing a light beam through an optically transparent wall portion of a container holding said aqueous portion during the ultraviolet laser treatment, through the aqueous portion in said container, out of said container through an optically transparent wall portion,

and into a spectrometer for monitoring the spectrophotometric signature of the aqueous portion during ultraviolet laser treatment.

18. A method according to claim 1 wherein the aqueous portion is exposed to the ultraviolet laser irradiation in a batch, semi-batch, or continuous flow process.

19. Apparatus for treating an aqueous solution and/or dispersion of selected chemical substance(s) so as to substantially completely decompose the chemical substance(s), said apparatus comprising in combination:

(a) a reaction vessel having an interior region to contain an aqueous portion containing the chemical substance(s);

(b) an ultraviolet laser proximate to said reaction vessel for generating an ultraviolet laser beam at a wavelength or wavelength range of about 180 nm to 400 nm; and,

(c) a window portion of said reaction vessel that is substantially transparent to ultraviolet laser radiation at wavelengths between about 180 nm to 400 nm to pass ultraviolet laser radiation from said laser into said interior region.

20. Apparatus according to claim 19 further wherein the ultraviolet laser beam is in alignment with said window portion of the reaction vessel for coupling laser light into the interior of the vessel.

21. Apparatus according to claim 19 further comprising an analytical system for continuously monitoring changes in the chemical composition of the aqueous portion in the reaction vessel during irradiation of the aqueous portion with ultraviolet laser radiation from the ultraviolet laser.

22. Apparatus according to claim 21 wherein said analytical system comprises a deuterium lamp device, a spectrometer, and a computer system.

23. Apparatus according to claim 22 wherein said deuterium lamp device is positioned to deliver one or more beams of light into an optically transparent wall portion of the reaction vessel, through the interior region of the reaction vessel including through the aqueous portion therein, out through an optically transparent wall portion of the reaction vessel, and thereafter into the spectrometer.

24. Apparatus according to claim 19 wherein said reaction vessel comprises a quartz tube.

25. Apparatus according to claim 19 wherein the area and shape of said window portion of said reaction vessel is substantially the same as the area and shape of a cross-section of the laser beam generated by the ultraviolet laser.

26. Apparatus according to claim 19 wherein said ultraviolet laser generates a pulsed laser beam capable of delivering an energy density in the range of about 0.10 millijoules to 1 joule per square millimeter per pulse to the aqueous portion at a pulse rate of about 1 to 50,000 pulses per second.

27. Apparatus according to claim 19 wherein said ultraviolet laser generates a monochromatic laser beam at a wavelength between about 180 nm and 193 nm.

28. Apparatus according to claim 19 wherein said reaction vessel includes fluid inlet and fluid outlet ports such that said aqueous portion can be continuously flowed through the interior region of said reaction vessel.

29. Apparatus according to claim 28 further comprising valves associated respectively with said fluid inlet and outlet ports for alternately stopping or resuming fluid flow.

30. Apparatus according to claim 28 wherein said aqueous portion is flowed through said reaction vessel in a direction of flow opposite to the direction of the ultraviolet laser beam through the vessel.